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TECHNICAL REPORT

NO. 12888

TACOM PHASE III MICV/GT601/X-300 FINAL TEST REPORT

CONTRACT NUMBER DAAE07-82-C-4109

JULY 1984

by GARRETT TURBINE ENGINE COMPANY
A DIVISION OF THE GARRETT CORPORATION

PHOENIX, ARIZONA

GARRETT REPORT
NO. 51-2732

U.S. ARMY TANK-AUTOMOTIVE COMMAND
RESEARCH AND DEVELOPMENT CENTER
Warren, Michigan 48090

TACOM PHASE III MICV/GT601/X-300

FINAL TEST REPORT

51-2732

July 31, 1984

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GARRETT TURBINE ENGINE COMPANY
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PHOENIX, ARIZONA

TACOM PHASE III MICV/GT601/X-300
FINAL TEST REPORT

INTRODUCTION

This report summarizes the results of TACOM Phase III Demonstration Testing conducted at the General Motors (GM) proving grounds at Milford, Michigan. Testing was conducted January 4 through 18, March 24 through 30, and completed June 7 through June 9, 1983, under the provisions of Contract DAAE07-82-C-4109.

The purpose of this program was to demonstrate the characteristics of the Garrett GT601 gas turbine engine mated with a Detroit Diesel Allison (DDA) X-300 transmission without a torque converter installed in a mechanized infantry combat vehicle (MICV) loaded to 45,000 pounds gross vehicle weight (GVW).

Phase III program objectives successfully accomplished were:

- Section 1 - Determination of the effect of engine power turbine variable vane geometry on vehicle braking (vane braking)
- Section 2 - Determination of the practical limit for engine air cleaner blockage, with blockages in excess of those tested in Phase II
- Section 3 - Evaluation of the effect of power turbine inertia on the gear train during vehicle braking
- Section 4 - Determination of the effect of forward-reverse-forward maneuvers on the engine and transmission
- Section 5 - Determination of vehicle balance speed on a 60-percent grade

Included herein for each test section are summaries of test program results, discussions of testing, and conclusions and recommendations. Test data sheets specified in various sections of this report are contained in Appendix A.

1- VANE-BRAKING TEST RESULTS

1-1 Test Purpose

The purpose of these tests was to quantify the effect of the GT601 engine power turbine variable vane geometry on vehicle braking.

1-2 Summary of Test Results

The first portion of this test was performed on a level dry track. The vehicle was loaded to 45,000 pounds GVW prior to test initiation. Table 1 shows the results of this test.

TABLE 1. DECELERATION ON LEVEL TRACK

Transmission Gear	Neutral				Fourth Range			
Deceleration Time, seconds		6.2	13.3	20.3		4.5	10.2	15.4
Left output shaft, rpm	2820	2078	1385	692	2800	2078	1385	692
Vehicle speed, MPH	40.7	30	20	10	40.4	30	20	10

For the second part of the vane-braking test the vehicle was run on various dry downgrades. Table 2 shows the results of this test.

TABLE 2. BALANCE SPEED ON DOWNGRADE

Transmission Gear	Neutral			Fourth Range		
Percent grade	7.2	10	16	7.2	10	16
Steady state time, seconds	760	20	Note 1	19	30	15
Left output shaft, rpm	170	1050	--	390	390	725
Vehicle speed, MPH	2.5	15.2	>45	*5.6	*5.6	10.5

*Power turbine idle speed

NOTE 1: During this phase of the test it was not possible to achieve a steady-state speed. The data shows a constant acceleration on the 16-percent grade. Vehicle speed reached 45 MPH before the brakes were applied.

1-3 Discussion

The test was conducted in accordance with Test Procedure 51-2694. For level track deceleration the vehicle was accelerated to a maximum steady-state speed of approximately 40 MPH in fourth range. To demonstrate vane braking the vehicle was allowed to decelerate in fourth range and data points were recorded. The test was then repeated except at maximum steady state speed the transmission was shifted to neutral and data again recorded during deceleration.

The data presented in Table 1 shows that the vehicle decelerated 25- to 28-percent faster in gear with vane braking than in neutral. Without vane braking, a gas turbine engine would continue to apply power in gear which would result in a slower deceleration than that achieved in neutral.

To determine the effect of vane braking on downhill balance speed the vehicle was driven down various grades in neutral and in gear. The grades selected were 7.2-percent, 10-percent, and 16-percent.

Vehicle balance speed in neutral down the 7.2-percent grade, was 2.5 MPH. As discussed in the Phase II report, the engine will automatically bring the power turbine to an "idle" speed of approximately 25-percent rpm when the throttle is not applied. Therefore, in fourth range, vehicle speed increased to 5.6 MPH on the 7.2-percent grade. The transmission automatically selected third gear for the balance speed. Had the transmission been manually shifted to first gear, the speed would have decreased to below 2.5 MPH. However, since the purpose of the test was to show the effect of vane braking on normal driving, no manual shifts were made during testing.

On the 10-percent grade the vehicle speed in neutral was 15.2 MPH. In fourth range, the transmission again selected third gear and this time the vehicle slowed to the same idle speed of 5.6 MPH. The slower speeds possible in lower gears were not demonstrated.

On the 16-percent grade the vehicle did not achieve a balance speed in neutral. At 45 MPH, the vehicle was still accelerating at 1 MPH/sec. In fourth range, a balance speed of 10.5 MPH was maintained in third gear. Again, manually downshifting would have resulted in a slower speed.

1-4 Conclusion

The distinct advantages of power turbine vane braking, which is unique to the GT601, were demonstrated. Vane braking provides enhanced drivability as well as the ability to maintain low speeds on downgrades without vehicle brake application.

2- INLET BLOCKAGE TEST RESULTS

2-1 Test Purpose

The purpose of this test was to determine the practical limit for engine air cleaner blockage, with blockages in excess of those tested in Phase II.

2-2 Summary of Test Results

The vehicle loaded to 45,000 pounds GVW demonstrated the effects of inlet blockage as shown in Table 3.

TABLE 3. EFFECTS OF INLET BLOCKAGE

Inlet Configuration	Inlet ΔP at 100% N_{GG} in-H_2O	0-20 MPH, sec	0-30 MPH, sec	200 Meters		Inlet Air Temperature, °F
				sec	MPH	
Blocked	21	7.5	18.0	20.7	32.0	54
↓	30	8.4	21.2	21.6	30.0	59
	40.6	9.7	--	23.1	28.0	64
Blocked	53	12.5	--	24.8	24.7	80
Open	12.5	7.0	15.6	20.0	34.0	35

The above results also are presented in Figure 1.

2-3 Discussion

The test was conducted in accordance with Test Procedure 51-2693. Figures 2 and 3 show the method used to simulate inlet blockages.

The blockages tested represent possible field blockage of barrier filters over a time period. The additional blockages tested exceed allowable M1 blockages by 26 in-H_2O, and exceed the absolute inlet system depression limit of 50 in-H_2O specified for the M1.

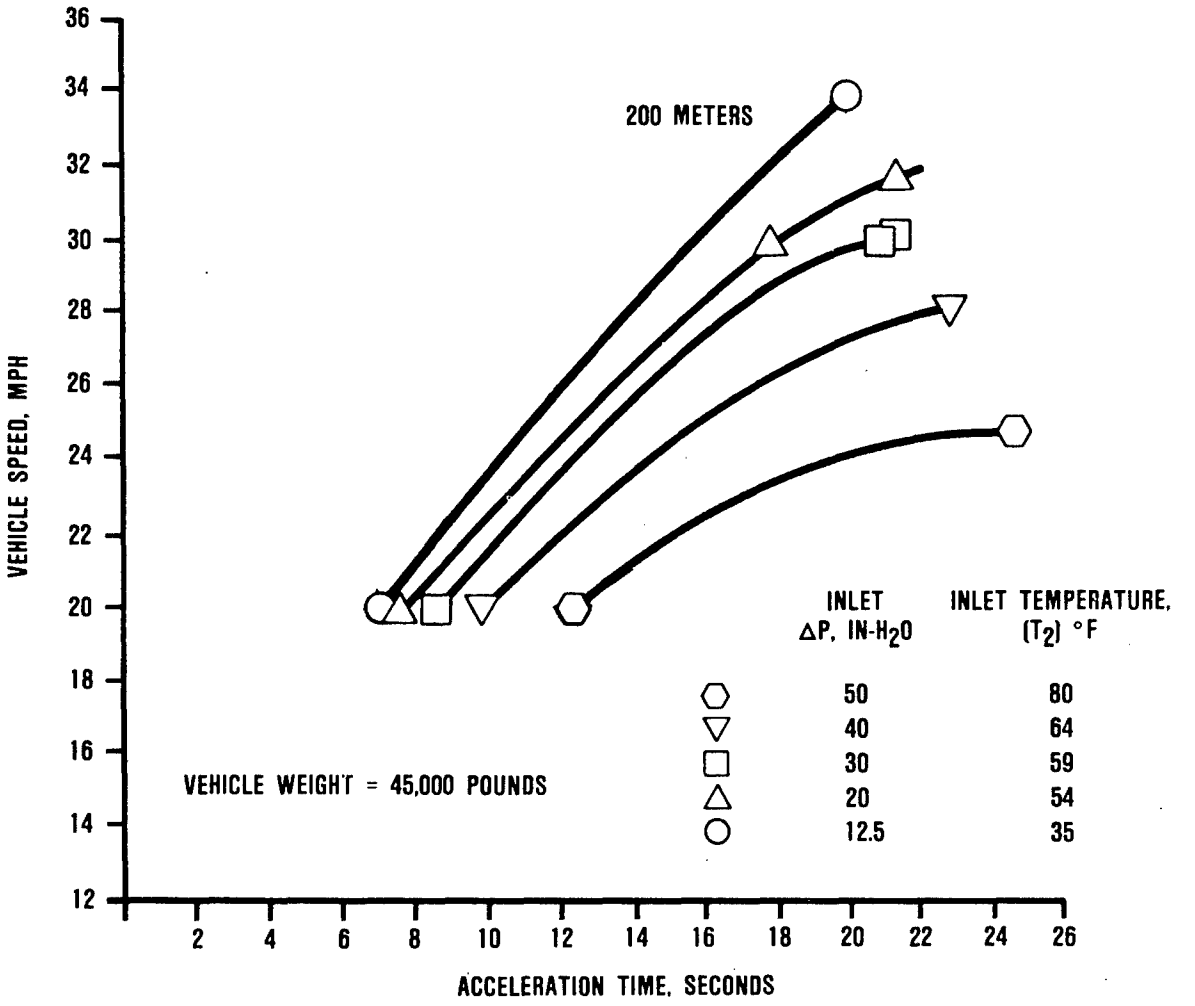

Figure 1. Inlet Blockage Test Results.

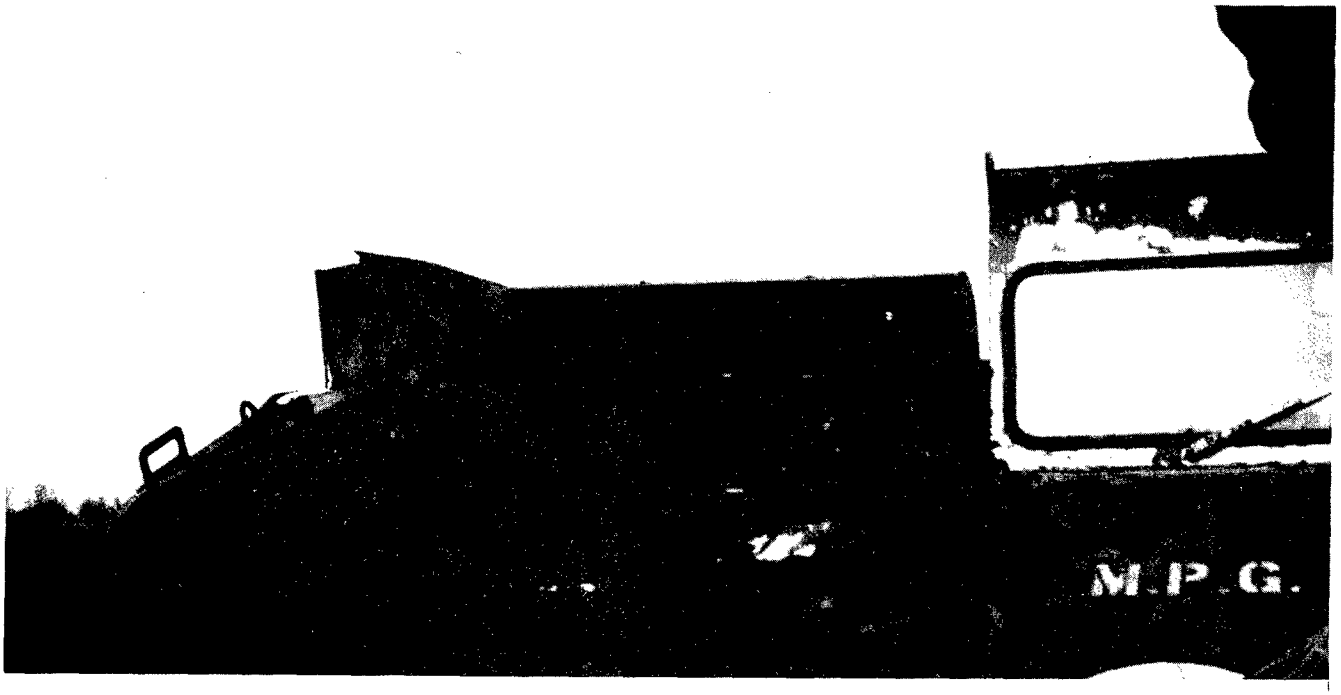

Figure 2. Open Inlet for Inlet Blockage Test.

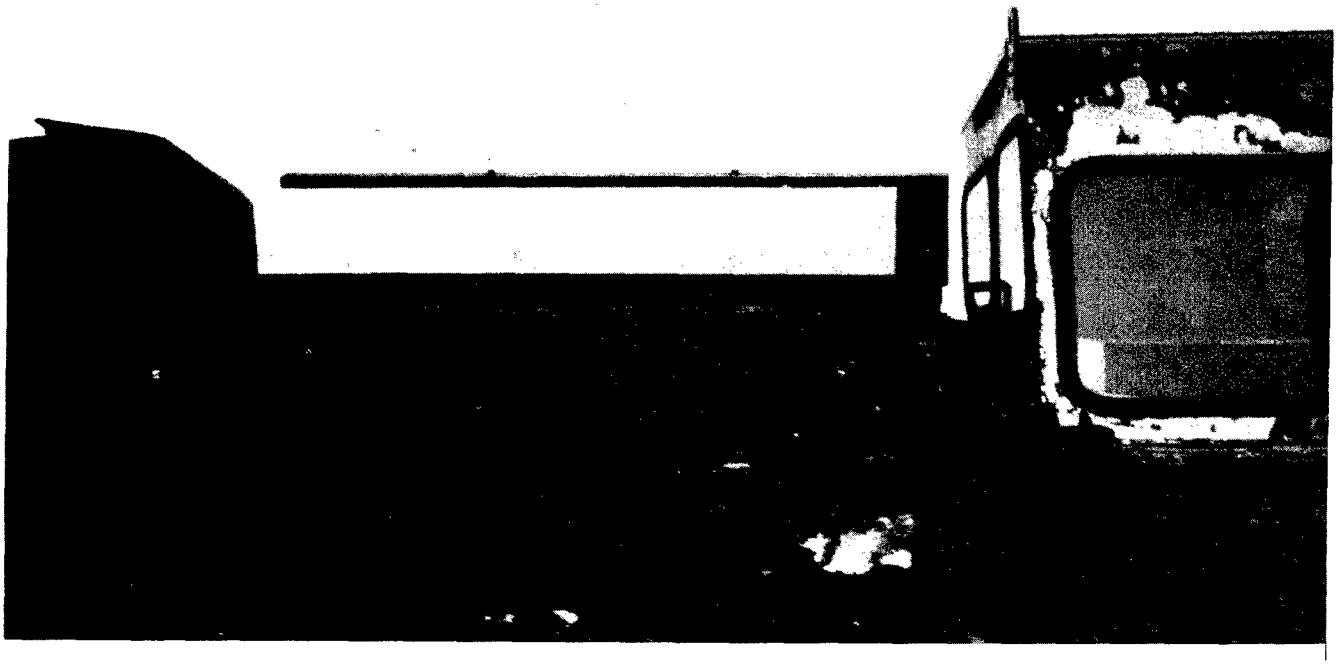

Figure 3. Inlet Blocked to 50 in-H_2O ΔP for Inlet Blockage Test.

A failed inlet filter exhaust fan that discharges through the engine exhaust duct resulted in higher inlet temperatures during this phase of testing because of hot exhaust gases being recirculated into the engine inlet. Had the hot exhaust gas not been recirculated the 200-meter dash to cover times would have shown even less deterioration with blockage.

Engine function was not adversely affected by inlet blockage.

2-4 Conclusions and Recommendations

A blockage that resulted in an additional 40 in-H_2O pressure drop in the engine inlet system resulted in only a 24-percent increase in the elapsed time required for the 200-meter dash to cover. The engine suffered no adverse affects from a 55 in-H_2O inlet depression other than reduced power output. The blockage limit was established by the present limit of 50 in-H_2O on the AGT1500 in the M1 tank. Still higher blockages without affecting mechanical integrity are possible with the GT601.

Testing at the Yuma Proving Ground is recommended to evaluate various inlet filter systems and demonstrate GT601 ability to operate in extreme sand and dust conditions.

3- MAXIMUM BRAKING TEST RESULTS

3-1 Test Purpose

The purpose of these tests was to evaluate the effect of power turbine inertia on the gear train during vehicle braking.

3-2 Summary of Test Results

The vehicle, loaded to 45,000 pounds GVW, demonstrated the effects of power turbine inertia on the gear train during vehicle braking as shown in Table 4.

TABLE 4. POWER TURBINE EFFECTS DURING BRAKING

Run No	Vehicle Speed, MPH	Time to Stop, Seconds	Gear Range	Maximum Torque at Left Output Shaft lb-ft
1	8.8	0.98	Fourth Auto	5162
2	18.7	1.95		5346
3	29.0	3.30		5162
4	9.5	1.20	Neutral	5162
5	17.3	1.70		6158
6	29.0	2.60		5531
7	40.4	4.62	Fourth Auto	5531

3-3 Discussion

The test was conducted in accordance with Test Procedure 51-2696. The maximum braking test was conducted on a dry level paved track.

As shown in Table 4 runs were performed in fourth range at increasing speeds, then the brake was applied. Three additional runs were performed at increasing speeds with the transmission shifted to

neutral prior to applying the brake. Comparing Runs 1, 2, and 3 with Runs 4, 5, and 6, the torque and times to stop are not significantly different.

3-4 Conclusion

Power turbine inertia does not have any adverse affects on the gear train during vehicle braking.

4- FORWARD-REVERSE-FORWARD MANEUVERS

4-1 Test Purpose

The purpose of this test was to determine the effect of forward-reverse-forward maneuvers on the engine and transmission.

4-2 Summary of Test Results

Table 5 summarizes the results of the forward-reverse-forward maneuvers.

TABLE 5. FORWARD-REVERSE-FORWARD MANEUVERS

Test No	Shift Range	Speed at Start of Shift, MPH	Maximum Torque at Left Output Shaft, lb-ft
1	*F to R	3.9	1843
	R to F	2.1	1475
2	F to R	6.3	2212
	R to F	2.8	2138
3	F to R	8.0	2138
	R to F	4.3	2286
4	F to R	7.9	2286
	R to F	5.5	2655
5	R to F	6.0	4720

*F = fourth range automatic gear
R = reverse gear

4-3 Discussion

The test was conducted in accordance with Test Procedure 51-2695. The vehicle was loaded to 45,000 pounds GVW and the test was conducted on a dry level track. The vehicle was accelerated to steadily increasing speeds and power levels before the shifts were made from forward to reverse or vice versa.

Test 4, shown on Table 5, is a shift from forward to reverse at full throttle. At this point the vehicle was traveling approximately 10 MPH. The shift was made forward to reverse. The transmission inhibitor allowed the vehicle to slow to 7.9 MPH before the shift was made. The peak torque was 2286 lb-ft or 41-percent of the transmission limit of 5500 ft-lb established by DDA for satisfactory transmission life.

Test 5 shown on Table 5 is a shift from reverse to forward at full throttle. The shift was made with the engine governor holding the vehicle speed at 6 MPH. The shift to forward was made. The peak torque was 4720 lb-ft or 85-percent of the transmission limit of 5500 ft-lb.

4-4 Conclusion

The forward-reverse-forward maneuvers did not adversely affect engine or transmission integrity. In all cases the maximum output shaft torque stayed below the values experienced during vehicle braking as presented in Section 3.

5- VEHICLE GRADABILITY TEST RESULTS

5-1 Test Purpose

The purpose of this test was to determine vehicle balance speed on a 60-percent grade.

5-2 Summary of Test Results

The vehicle, loaded to 45,000 pounds GVW demonstrated the balance speed shown in Table 6 on a 60-percent grade.

TABLE 6. BALANCE SPEED (60-PERCENT GRADE)

Percent Grade	Balance Speed, MPH	Engine Inlet Air Temperature (T_2), °F
60	4.7	75

The above test point balance speed (60-percent grade) is presented in Figure 4. Figure 4 also shows the predicted balance speeds for 59°F, sea level conditions. This figure previously was presented in TACOM Phase II MICV/GT601/X-300 interim Test Report 51-2669. Figure 5 shows the vehicle ascending the 60-percent grade.

5-3 Discussion

The test was conducted in accordance with Test Procedure 51-2692 on June 9, 1983.

Figure 4 is discussed in the Phase II TACOM report. The 60-percent gradability test was performed in first gear on a dry track. A balance speed of 4.7 MPH was achieved on the 60-percent grade. The vehicle was then stopped at mid-grade. The driver held the vehicle at a complete stop for 9 seconds. At that point the vehicle was driven up the remainder of the 60-percent grade.

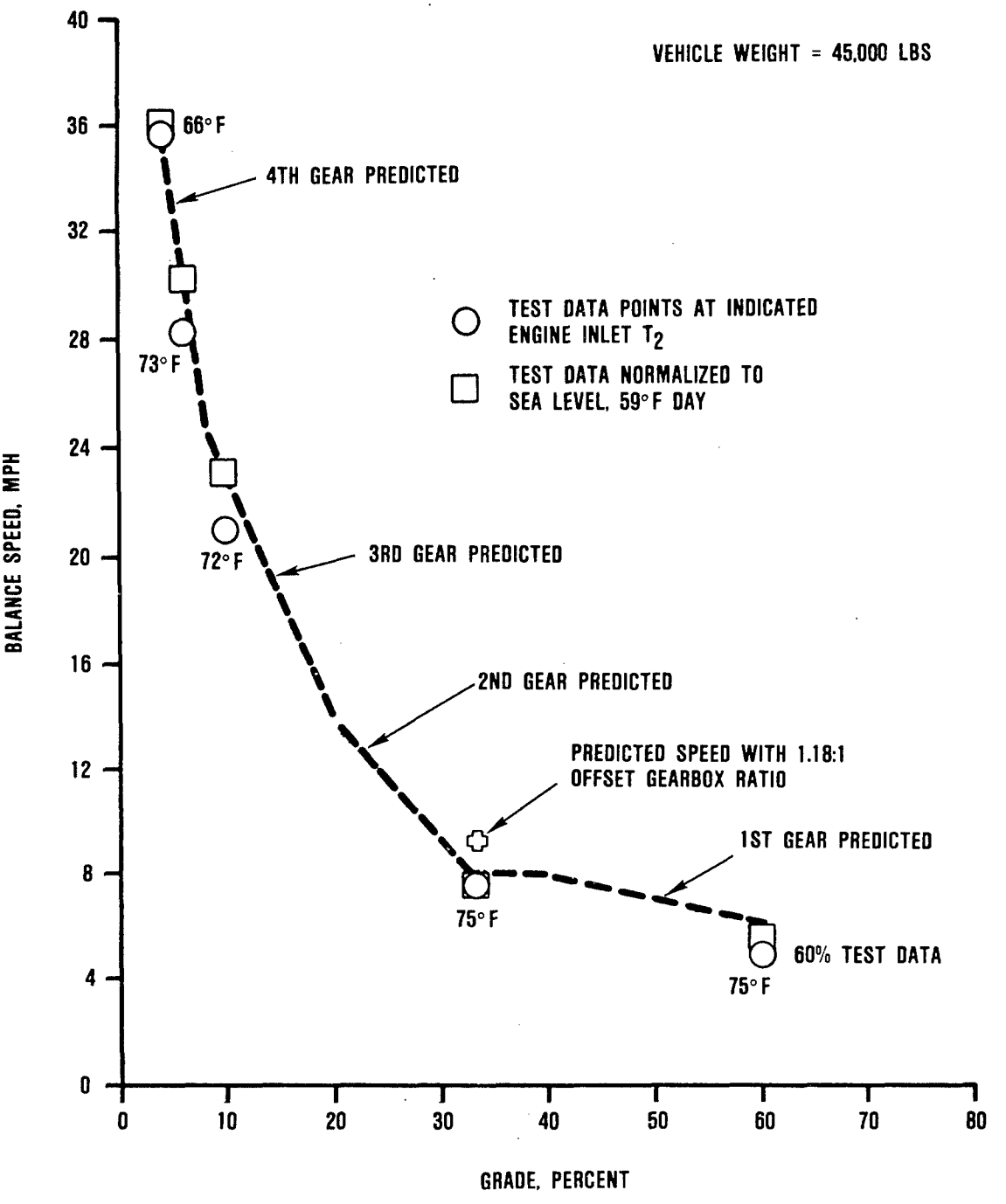

Figure 4. Gradability Test Results.

Figure 5. Vehicle Ascending the 60-Percent Grade.

5-4 Conclusion

The vehicle, loaded to 45,000 pounds GVW and powered by a GT601 engine, demonstrated the ability to negotiate grades up to 60-percent at speeds approximating computer predictions.

6- PHASE III SUMMARY

TACOM Phase III demonstration testing was conducted at the GM proving grounds at Milford Michigan. The tests and test dates are shown below:

- o January 6-14, 1983
  Vane Braking
  Inlet Blockage
  Maximum Braking

- o March 24-30, 1983
  Forward-Reverse-Forward

- o June 7-9, 1983
  Vehicle Gradability (60-percent)

The test vehicle was a MICV loaded to 45,000 pounds GVW. The powerpack consisted of a Garrett GT601 gas turbine engine mated to a DDA X-300 transmission without a torque converter.

Referenced to the preceding report section, the following five program objectives were successfully accomplished.

- o Section 1 - Quantify the effects of variable vane geometry on vehicle braking
- o Section 2 - Determine that the limit for air cleaner blockage is equal to or better than that established for the M1 tank
- o Section 3 - Evaluate the effect of power turbine inertia on the gear train during vehicle braking
- o Section 4 - Determine the effects of forward-reverse-forward maneuvers

- Section 5 - Determine vehicle balance speed on a 60-percent grade

During the Phase III test period, the GT601 accumulated 120 starts, 15 hours of operation, and 173 miles of travel. No mechanical powerpack problems were experienced during Phase III testing.

Since installed in the MICV the GT601 has accumulated a total of 347 automatic starts, 128 hours of operation, and 1248 miles of travel.

The conclusions for each of the Phase III objectives are summarized below.

- Section 1 - Vane Braking - Vane braking, a feature unique to the GT601, provides enhanced drivability without vehicle brake application
- Section 2 - Inlet Blockage - The engine showed no adverse affects from a 55 in-H_2O inlet depression other than reduced power output
- Section 3 - Maximum Braking - Power turbine inertia does not have any adverse affects on the gear train during vehicle braking
- Section 4 - Forward-Reverse-Forward Maneuvers - This maneuver did not adversely affect engine or transmission integrity
- Section 5 - Gradability - The GT601-powered vehicle demonstrated the ability to maintain a balance speed approximating computer predictions on a 60-percent grade.

APPENDIX A

TEST DATA

The data contained in this appendix were obtained during Phase III testing. Testing was conducted at the GM proving grounds at Milford, Michigan. The test vehicle was a MICV loaded to 45,000 pounds GVW powered by a Garrett GT601 gas turbine engine mated with a DDA X-300 transmission without a torque converter.

TACOM PHASE III DEMONSTRATION
ENGINE VANE-BRAKING EFFECTS (LEVEL TERRAIN)
TEST DATA SHEET

DS-4399

Date 11 Jan 83 Engine S/N 008 Transmission S/N 13 Fuel Type DF-2

Technician Buehman Engineer Eckstat TACOM Rep Notified

Item	Unit	Transmission in Neutral				Transmission in 4th Range			
		Maximum Steady-State Speed	30 MPH	20 MPH	10 MPH	Maximum Steady-State Speed	30 MPH	20 MPH	10 MPH
*Deceleration Time (1-Second Marker)	sec	40.7	6.2	13.3	20.3	40.4	4.5	10.2	15.4
Ambient Air Temperature (Dry Bulb)	°F	64	→	→	→	→	→	→	64
Relative Humidity	%	100	→	→	→	→	→	→	100
Barometric Pressure	in-HgA	28.12	→	→	→	→	→	→	28.12
Wind Speed and Direction	MPH	W 10.9	→	→	→	→	→	→	W 10.9
Engine Inlet Air Temperature	°F	40	40	40	40	39	39	39	39
Engine Oil Temperature	°F	160	160	160	160	158	158	158	158
Oil Temperature into Transmission/Sump	°F	152/175			152/175	148/173			148/173
*Gas Generator Speed	rpm	37,300	28,000	27,800	27,800	37,300	27,400	27,000	27,000
*Power Turbine Speed	rpm	26,300	10,700	8400	8400	26,000	19,200	12,800	10,000
*Variable Turbine Nozzle Vane Position	vdc	3.2	BRAKE	BRAKE	BRAKE	3.2	BRAKE	BRAKE	BRAKE
*Throttle Position	vdc	FULL	OFF	OFF	OFF	FULL	OFF	OFF	OFF
*Left Output Shaft (Vehicle Speed)	rpm	2820	2078	1385	692	2800	2078	1385	692
	MPH	40.7	30	20	10	40.4	30	20	10
*Turbine Inlet Temperature	°F	1820	→	→	→	1815	→	→	→
*Recuperator Inlet Temperature	°F	1120	1120	1160	1020	1115	1120	1150	1140

*Items to be continuously recorded.

TACOM PHASE III DEMONSTRATION
ENGINE VANE-BRAKING EFFECTS (DOWNGRADES)
TEST DATA SHEET

DS-4500

Date January 11-12, 1983 Engine S/N 008 Transmission S/N 13 Fuel Type DF-2

Technician Buehman Engineer Eckstat TACOM Rep Notified

Item	Unit	Transmission in Neutral			Transmission in 4th Range		
Percent Grade		7.2	10	16	7.2	10	16
*Steady-State Time (1-Second Marker)	sec	>60	20	-0-	19	30	15
Ambient Air Temperature (Dry Bulb)	°F	51	64	51	51	64	51
Relative Humidity	%	66	100	66	66	100	66
Barometric Pressure	in-HgA	28.7	28.12	28.7	28.7	28.12	28.7
Wind Speed and Direction	MPH	NNW 10.9	W 10.9	NNW 10.9	NNW 10.9	W 10.9	NNW 10.9
Engine Inlet Air Temperature	°F	28	40	29	28	42	28
Engine Oil Temperature	°F	160	160	158	163	162	161
Oil Temperature into Transmission/Sump	°F	164/168	161/178	162/168	169/174	146/168	160/168
*Gas Generator Speed	rpm	27,300	27,000	--	27,500	27,000	27,500
*Power Turbine Speed	rpm	8200	9000	--	8400	8400	15,500
*Variable Turbine Nozzle Vane Position	vdc	NPT Idle	NPT Idle	NPT Idle	NPT Idle	NPT Idle	Full Braking
*Throttle Position	vdc	OFF	→	→	→	→	OFF
*Left Output Shaft	rpm	170	1056	--	390	390	725
(Vehicle Speed)	MPH	2.5	15.2	--	5.6	5.6	10.5
*Turbine Inlet Temperature	°F	1040	1260	--	1160	1240	1160
*Recuperator Inlet Temperature	°F	880	1080	--	920	1080	1060

*Items to be continuously recorded.

GARRETT TURBINE ENGINE COMPANY
A DIVISION OF THE GARRETT CORPORATION
PHOENIX ARIZONA

DS-4398

TACOM PHASE III DEMONSTRATION
INLET BLOCKAGE EFFECTS
TEST DATA SHEET

DS-4398
Date 12 Jan 83 Engine S/N 008 Transmission S/N 13 Fuel Type DF-2
Technician Buehman Engineer Eckstat Tacom Rep Notified

Item	Unit	Test Points With Blockage			Test Points Without Blockage		
		20 MPH	30 MPH	200 Meters	20 MPH	30 MPH	200 Meters
Ambient Air Temperature (Dry Bulb)	°F				50	→	→
Relative Humidity	%				71	→	→
Barometric Pressure	in-HgA				28.69	→	→
Wind Speed and Direction	MPH				5.0 NNW	→	→
Vehicle Inlet Grill Air Temperature	°F				20	20	20
Engine Inlet Air Temperature	°F				35	35	35
Engine Oil Temperature	°F				158	158	158
Oil Temperature into Transmission/Sump	°F				163/170	163/170	163/170
*ΔP Inlet Grill to Engine Inlet	in-H_2O ΔP				13.0	12.3	12.7
*Gas Generator Speed	rpm				37,400	36,600	37,900
*Power Turbine Speed	rpm				19,400	19,300	22,000
*Left Output Shaft (Vehicle Speed)	rpm/MPH				1385/20	2078/30	2350/34
*Variable Turbine Nozzle Vane Position	vdc				NULL	NULL	NULL
*Throttle Position	vdc				FULL	FULL	FULL
* Turbine Inlet Temperature	°F				1800	1888	1920
*Recuperator Inlet Temperature	°F				1135	1145	1168
*Elapsed Time (1-second marker)	minutes				7.0	15.6	20.0

*Items to be continuously recorded.

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PHOENIX, ARIZONA

DS-4398

TACOM PHASE III DEMONSTRATION
INLET BLOCKAGE EFFECTS
TEST DATA SHEET

DS-4398
Date 12 Jan 83 Engine S/N 008 Transmission S/N 13 Fuel Type DF-2
Technician Buehman Engineer Eckstat Tacom Rep Notified

Item	Unit	Test Points With 20 In-H_2O Blockage			Test Points With 30 In-H_2O Blockage		
		20 MPH	30 MPH	200 Meters	20 MPH	30 MPH	200 Meters
Ambient Air Temperature (Dry Bulb)	°F	50	→	→	→	→	→
Relative Humidity	%	71	→	→	→	→	→
Barometric Pressure	in-HgA	28.69	→	→	→	→	→
Wind Speed and Direction	MPH	5.0 NNW	→	→	→	→	→
Vehicle Inlet Grill Air Temperature	°F	19	19	19	20	20	20
Engine Inlet Air Temperature	°F	54	54	54	59	59	59
Engine Oil Temperature	°F	161	161	161	159	159	159
Oil Temperature into Transmission/Sump	°F	165/171	165/171	165/171	163/170	163/170	163/170
*ΔP Inlet Grill to Engine Inlet	in-H_2O ΔP	21.2	20.6	21.0	30.0	30.0	30.1
*Gas Generator Speed	rpm	37,200	37,100	37,500	37,200	37,300	37,500
*Power Turbine Speed	rpm	19,300	19,200	20,600	19,300	19,200	19,600
*Left Output Shaft (Vehicle Speed)	rpm/MPH	1385/20	2078/30	2200/32	1385/20	2078/30	2100/30
*Variable Turbine Nozzle Vane Position	vdc	NULL	→	→	→	→	→
*Throttle Position	vdc	FULL	→	→	→	→	→
* Turbine Inlet Temperature	°F	1832	1900	1905	1840	1915	1915
*Recuperator Inlet Temperature	°F	1172	1188	1200	1170	1220	1225
*Elapsed Time (1-second marker)	minutes	7.55	18	20.7	8.45	21.2	21.6

*Items to be continuously recorded.

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PHOENIX, ARIZONA

DS-4398

TACOM PHASE III DEMONSTRATION
INLET BLOCKAGE EFFECTS
TEST DATA SHEET

DS-4398
Date 12 Jan 83 Engine S/N 008 Transmission S/N 13 Fuel Type DF-2
Technician Buehman Engineer Eckstat Tacom Rep Notified

Item	Unit	Test Points With 40 In-H_2O Blockage			Test Points With 50 In-H_2O Blockage		
		20 MPH	30 MPH	200 Meters	20 MPH	30 MPH	200 Meters
Ambient Air Temperature (Dry Bulb)	°F	50	→	→	→	→	→
Relative Humidity	%	71	→	→	→	→	→
Barometric Pressure	in-HgA	28.69	→	→	→	→	→
Wind Speed and Direction	MPH	5.0 NNW	→	→	→	→	→
Vehicle Inlet Grill Air Temperature	°F	19		19	21		21
Engine Inlet Air Temperature	°F	64		64	80		80
Engine Oil Temperature	°F	158		158	159		159
Oil Temperature into Transmission/Sump	°F	163/171		163/171	164/169		164/169
*ΔP Inlet Grill to Engine Inlet	in-H_2O ΔP	40.9		40.4	51.2		55.5
*Gas Generator Speed	rpm	37,200		37,000	37,200		38,000
*Power Turbine Speed	rpm	19,300		18,000	19,300		24,200
*Left Output Shaft (Vehicle Speed)	rpm/MPH	1385/20		1440/28	1385/20		1715/24.7
*Variable Turbine Nozzle Vane Position	vdc	NULL		NULL	NULL		NULL
*Throttle Position	vdc	FULL		FULL	FULL		FULL
* Turbine Inlet Temperature	°F	1900		1880	1945		1900
*Recuperator Inlet Temperature	°F	1230		1240	1308		1276
*Elapsed Time (1-second marker)	minutes	9.75		23.1	12.5		24.8

*Items to be continuously recorded.

GARRETT TURBINE ENGINE COMPANY
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PHOENIX, ARIZONA

DS-4502

TACOM PHASE III DEMONSTRATION
MAXIMUM BRAKING EFFORT
TEST DATA SHEET

Date 1-12-83 Engine S/N 8 Transmission S/N 13 Fuel Type DF-2

Technician Cross Engineer Eckstat TACOM Rep Notified

Item	Unit	Nominal Starting Speed, MPH			
		10	20	30	Max
Ambient Air Temperature (Dry Bulb)	°F	46	46	46	55
Relative Humidity	%	76	76	76	34
Barometric Pressure	in-HgA	29.1	29.1	29.1	29.1
Wind Speed and Direction	MPH	Calm	Calm	Calm	6.02 SE
*Oil Temperature into Transmission	°F	167	167	167	203
*Transmission Oil Sump Temperature	°F	199	204	202	235
*Peak Torque at Left Output Shaft	lb-ft	5162	5346	5162	5531
*Left Output Shaft at Start of Deceleration	rpm	609	1294	2008	2797
(Vehicle Speed)	MPH	8.8	18.7	29.0	40.4
Gear Selector Location	range	Fourth Auto	→	→	→
Shift Quadrant Installed		2-4	→	→	→

*Items to be continously recorded.

GARRETT TURBINE ENGINE COMPANY
A DIVISION OF THE GARRETT CORPORATION
PHOENIX, ARIZONA

DS-4501

TACOM PHASE III DEMONSTRATION
FORWARD-REVERSE-FORWARD MANEUVERS
TEST DATA SHEET

Date March 13, 1983 Engine S/N 8 Transmission S/N 13 Fuel Type DF-2

Technician Cross Engineer Mascioli TACOM Rep Notified

Item	Unit	Run Number								
		1		2		3		4		5
Direction of Shift	gears	F-R	R-F	F-R	R-F	F-R	R-F	F-R	R-F	R-F
*Vehicle Speed at Time of Shift	MPH	3.9	2.1	6.3	2.8	8.0	4.3	7.9	5.5	6.0
*Power Turbine Speed at Shift Engagement	rpm	8700	9200	14,000	13,500	14,000	19,000	12,000	22,000	25,000
*Peak Torque at Left Output Shaft	lb-ft	1770	1475	3097	2138	2389	2286	1622	2655	4646
Maximum Power Turbine Decel Rate	rpm/sec	6300	19,200	14,000	18,500	7800	22,000	3000	30,000	30,000
Ambient Air Temp (Dry Bulb)	°F	57		57		57		67		67
Relative Humidity	%	32		32		32		50		50
Barometric Pressure	in-HgA	28.7		28.7		28.7		28.6		28.6
Wind Speed and Direction	MPH	2 SE		2 SE		2 SE		4 S		4 S
Engine Inlet Air Temperature	°F	73		73		73		73		73

*Items to be continuously recorded.

DS-4397

TACOM PHASE III DEMONSTRATION
VEHICLE GRADABILITY
TEST DATA SHEET

Date 6-8-83 Engine S/N 008 Transmission S/N 13 Type Fuel DF-2

Technician Cross Engineer Mascioli TACOM Rep _____

Item	Unit	Test Points 60-Percent Grade
Ambient Air Temperature (Dry Bulb)	°F	65.3
Relative Humidity	%	35
Barometric Pressure	in-HgA	29.03
Wind Speed and Direction	MPH	19.8 SSW
Vehicle Inlet Grill Air Temperature	°F	68
Engine Oil Temperature	°F	144
Oil Temperature into Transmission	°F	174
*Gas Generator Speed	rpm	37,000
*Power Turbine Speed	rpm	15,500
*Left Output Shaft (Vehicle Speed)	rpm/MPH	325/4.7
*Variable Turbine Nozzle Vane Position	vdc	OUT
*Throttle Position	vdc	FULL
*Turbine Inlet Temperature	°F	1860
*Recuperator Inlet Temperature	°F	1200
*Elapsed Time (1 second marker)	seconds	1.5

*Items to be continuously recorded.

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

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20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)* This report summarizes the results of TACOM Phase III Demonstration Testing conducted at the General Motors (GM) proving grounds at Milford, Michigan. Testing was conducted January 4 through 18, March 24 through 30, and completed June 7 through June 9, 1983, under the provisions of Contract DAAE07-82-C-4109. (over)		

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The purpose of this program was to demonstrate the characteristics of the Garrett GT601 gas turbine engine mated with a Detroit Diesel Allison (DDA) X-300 transmission, without a torque converter, installed in a mechanized infantry combat vehicle (MICV) loaded to 45,000 pounds gross vehicle weight (GVW).